forest management note

Note No. 32 **Northern Forestry Centre** **Edmonton, Alberta**

PROCOM-2 MAPPING TECHNIQUE FOR MONITORING FOREST DEPLETION

An economic, yet accurate, technique for monitoring forest depletion is required for effective forest management over large areas. About 10 000 maps, either by townships or 10-km UTM grid squares, are required to cover the combined forested areas of the three prairie provinces. Nearly as many again will be required for the forested areas of the Northwest Territories. Together, these maps form a base for managing Canada's forest resources in the Western and Northern Region, and they must be kept up-to-date as economically as possible.

Currently, survey data from a large variety of sources are available for the very large forested areas of Canada. For instance, aerial survey photography at scales of 1:40 000 to 1:70 000 are available from the National Air Photo Library, and provincial agencies have similar repositories containing aerial photography at scales of 1:10 000 to 1:50 000. The maps, reports, and related data banks produced from this survey photography are also routinely available. Unfortunately, most of the original photography is from 10 to 30 years old, and the resultant maps, data banks, and reports have been time-consuming and expensive to produce. These existing data provide a valuable base to work from, but current, location-specific (i.e., mapped) data about significant changes to forest resources are required.

Satellite imagery, particularly color transparencies, contain up-to-date information at a comparatively low cost; the challenge is in the interpretation and transfer of that data onto suitable map formats. Despite low LANDSAT imagery resolution (e.g., 70 m for 1:1 000 000 scale images), single features such as recently burned or clear-cut land and new roads are easily recognized and can be easily highlighted to separate them from a clutter of image detail. LANDSAT color transparencies, for example, are consistently produced at 1:1 000 000 or 1:500 000 scales. Images taken before and after the period monitored can be compared under a stereoscope on a light table. Although LANDSAT imagery is not stereo, differences between the two dates of coverage will appear to float above the terrain in the pseudostereoscopic image. The changes must then be accurately plotted on forest maps. The Procom-2 image transfer equipment[1] has proven to be efficient in accomplishing this. The area of change can also be digitized for inclusion in a digital data base. This note describes the adaptable, reliable, and simply constructed Procom-2 mapping equipment and provides some examples of Procom-2 use for forestry purposes.

DESCRIPTION OF THE PROCOM-2

The Procom-2 specifications are in Table 1. The steel frame of the Procom-2 is designed to fit on a standard desk top (Fig. 1). A quality projector with interchangeable zoom lenses is used to project portions of a transparency onto an overhead mirror and then onto a

[1] Produced by Gregory Geoscience Limited, 1794 Courtwood Crescent, Ottawa, Ontario K2C 2B5.

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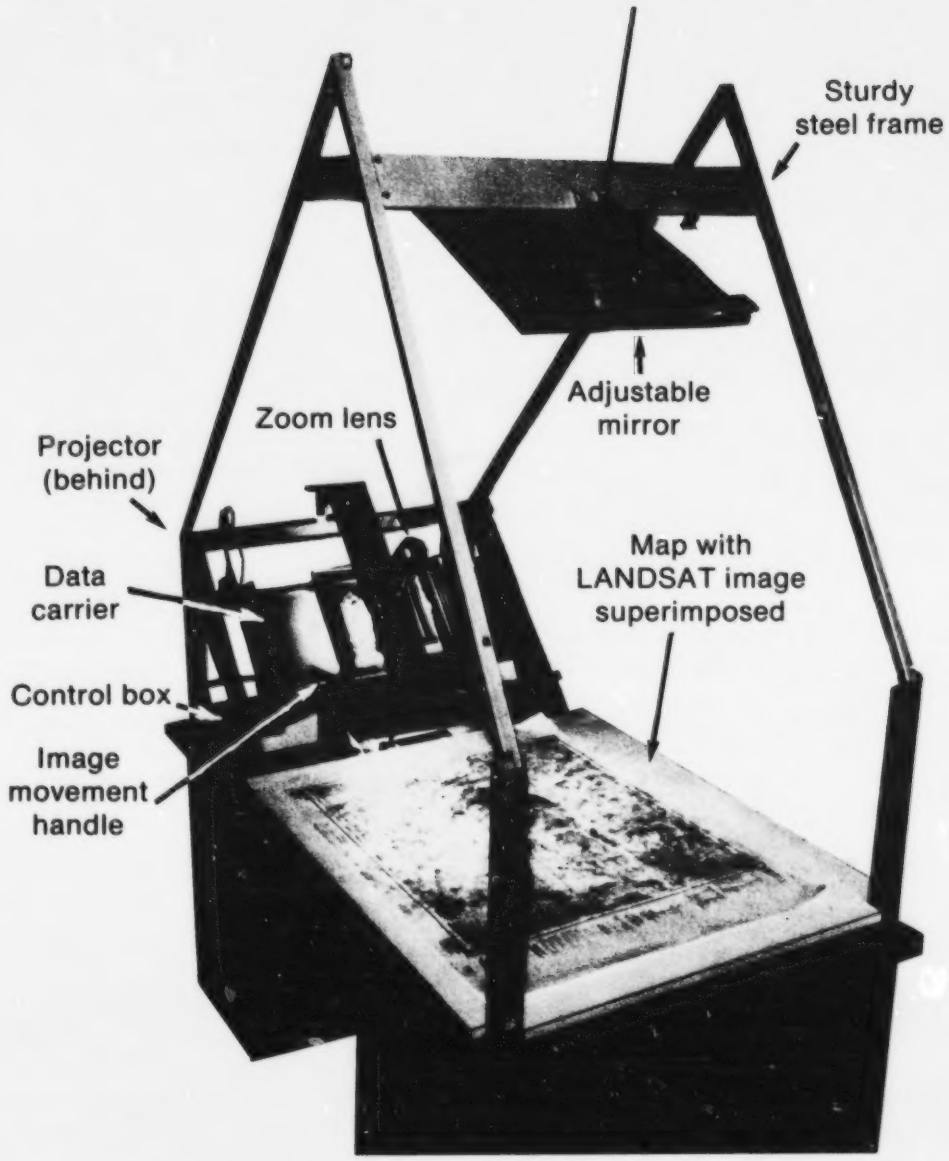

Figure 1. Procom-2 on desk top.

Table 1. Specifications for the Procom-2

Power:	110–240 V, 50–60 Hz
Size:	Height 138 cm (55 in.) Width 81 cm (32 in.) Length 157 cm (62 in.) Height for shipping 55 cm (22 in.)
Weight (net):	84 kg (185 lb.)
Viewing mode:	Reflected front projection
Beam deflector:	Aluminized front surface plane mirror, 40 × 40 cm
Lenses: Standard:	60–300 mm telemacro zoom, with 2× teleconverter 28–80 mm zoom
Optional:	A variety of interchangeable zoom lenses are available with Minolta mounts
Projector:	Modified scientific model with 24V, 250W halogen lamp and heat filter
Cooling:	2 path, adjustable, in projector; auxiliary blower for data carrier
Projection distance:	2.1 m (7 ft.), folded for convenient operation
Working area:	81 × 100 cm (32 × 39 in.), white arborite
Magnification:	6–28× using the 60–300 mm lens 3–14× with the 2× teleconverter 29–72× using the 28–80 mm lens Up to 100× with optional lenses

working surface in front of an interpreter seated at the desk. A full-size 1:1 000 000 scale LANDSAT transparency is easily fitted into the data or film carrier. A handle on the carrier allows it to be moved easily and smoothly in the X and Y axes through the focal plane of the projector. The whole image can be searched under magnification in this manner, and selected portions of it can be adjusted with the zoom lenses to fit specific maps on the working surface. Optional lenses are available; the Northern Forestry Centre (NoFC) equipment has 3 to 80 times enlargement capabilities.

The Procom-2 with standard lenses, copy-camera mount, and maintenance kit costs $14,000 as of March 1986. An optional lens ($350), two digitizing tablets ($4,500 and $5,500), and a roll-film adapter ($1,500) are also available. For digital outputs, a cursor on a tablet replaces the traditional pen or pencil to follow the outlines of changes evident in the imagery on the map.

The operator of the Procom-2 is an interpreter. Most of the operator's attention can be directed to the actual mapping rather than to mastering equipment technology. For instance, a forestry contractor was employed to produce the forest land area statistics for the noninventoried regions of the prairie provinces with the NoFC Procom-2. The contractor had little experience with satellite imagery and no experience with the Procom-2. Knowledge of regional forestry and land use was more important, and LANDSAT imagery and Procom-2 characteristics and operations were quickly learned and applied. Subsequent field checks indicated that the contractor had sufficient competence with the technique for the level of statistical accuracy required for that particular task.

The Procom-2 supplier, Gregory Geoscience Limited, is a resources exploration consulting firm and not a hardware manufacturer. The Procom-2 was developed as a cost-effective working tool for their resource survey activities. Gregory Geoscience conducted a pilot study for the Canadian Forestry Service on mapping efficiencies of the Procom-2 (Moore and Jeffery 1983). The objective of that pilot study was to develop and demonstrate techniques with LANDSAT imagery to detect, classify, map, and measure annual forest depletions. The study used three separate test sites of 50 townships each. Of the five possible depletion classes (harvest, withdrawals, burned, wind damaged, and unknown) only harvest and withdrawals were detected in the test areas. A total of 193 depletions, totaling 1250 ha, were mapped; 78% of the depletions were due to harvesting. Most of the withdrawals were for agriculture expansion. Roads were also added to a number of township maps to demonstrate the usefulness of LANDSAT imagery for updating forest accessibility. The cost of the pilot study was $0.72/km^2, but should be less than one-half of that unit area cost in an operational program for much larger areas. The costs would also be less than one-tenth of the overall costs of any aerial survey technique for map updating. Fieldwork requirements would be the same.

NoFC USE OF THE PROCOM-2

An objective of NoFC is to evaluate, develop, and apply new remote sensing techniques for forest inventories and environmental management purposes in col-

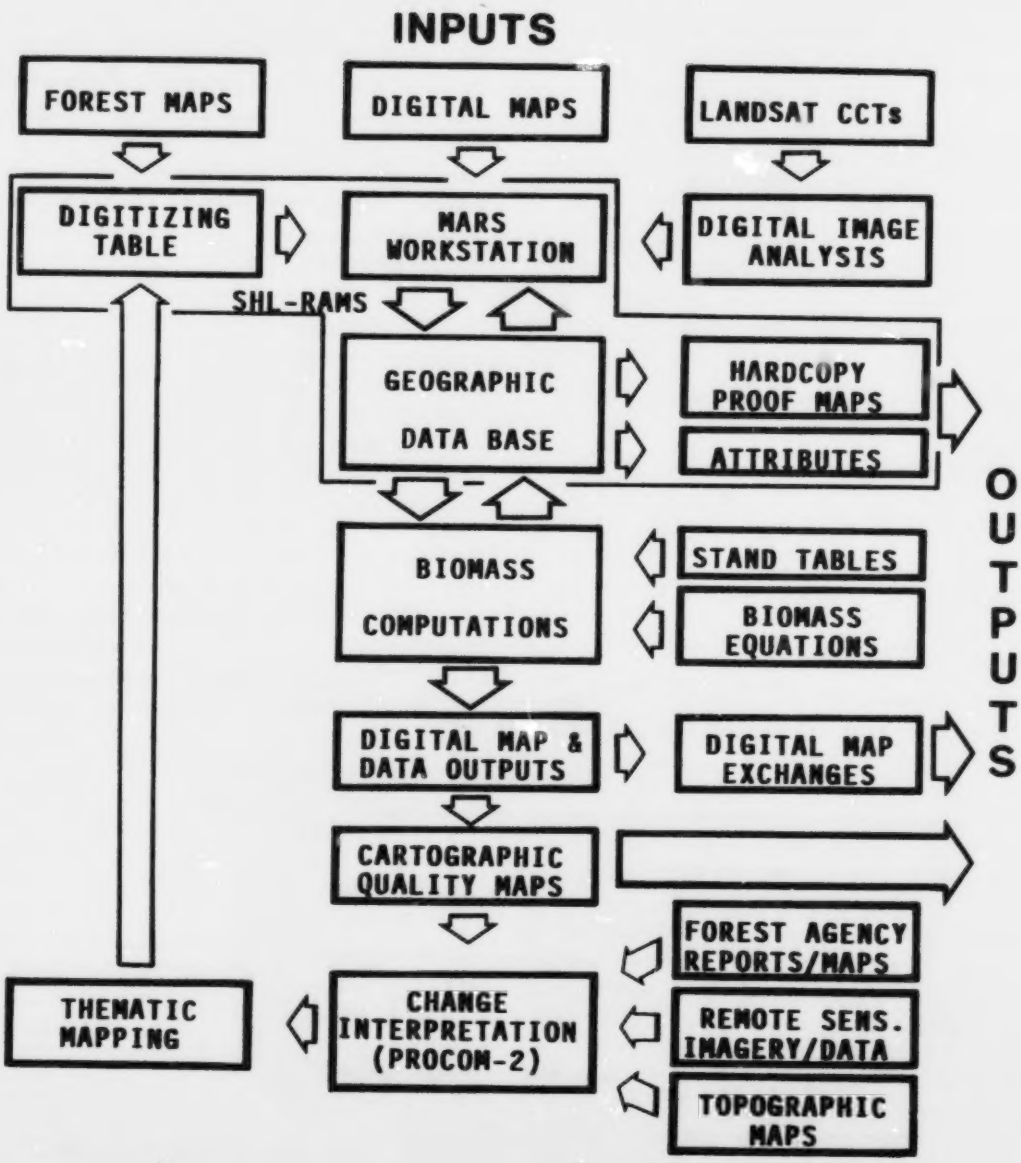

Figure 2. Mapping and Analysis of Resources System (MARS) flowchart for an example forest inventory to biomass inventory case study featuring the Procom-2 for forest depletion updates: SHL-RAMS is the Systemhouse Limited computerized Geographic Information System (GIS) that is central to MARS; CCTs are computer compatible tapes (e.g., LANDSAT data).

laboration with other agencies. This has been accomplished largely through studies with dual purposes. Three of these studies are briefly described here to illustrate use of the Procom-2 as a working tool.

Mapping Burned Land in the Northwest Territories

The use of LANDSAT imagery was demonstrated for monitoring burned-over forest land in the Northwest Territories (NWT) from year to year[2]. A summary forest inventory covering about 1 092 920 km² in the southern and western parts of the NWT on 1:250 000 scale topographic maps was used for a map base. Sixty-nine full-frame LANDSAT color transparencies were required for 85 of the map sheets. Traditional aerial photograph-to-map transfer techniques were first attempted, but they were unsuitable for a variety of reasons; either they were too time-consuming, expensive, or inaccurate. The Procom-2 was evaluated once it became available, and it was eminently suitable. Several LANDSAT and aerial survey techniques were quantitatively compared and subjectively evaluated; the Procom-2 was a cost-effective tool for accurately combining imagery and maps. It has also been operationally demonstrated for other survey uses (Fleming 1982).

Burned forest land delineated on forest maps of Alberta and Saskatchewan at 1:15 000 and 1:12 500 scales, respectively, was also subjectively compared with LANDSAT image transparencies on the Procom-2. The LANDSAT—Procom-2 technique was more reliable than aerial sketch-mapping, but the two techniques should be combined. Medium-scale aerial photography was expected to be more accurate because of the detail resolved but more expensive and time-consuming to use. All of these techniques can be combined, with sketch mapping and high resolution aerial survey diapositives (transparencies) used to selectively corroborate LANDSAT—Procom-2 delineations and to survey areas of higher priority. The increased spectral and spatial resolution of the LANDSAT Thematic Mapper sensor (i.e., 30 m resolution and 1:500 000 scale transparencies) could provide additional opportunities for increasing the operational productivity and cost-effectiveness of LANDSAT—Procom-2 techniques in the near future. The significantly increased costs of the imagery are only a small component of overall project costs.

Producing National Biomass Estimates

The LANDSAT—Procom-2 technique was also used to obtain forested land area statistics by township in the parklands and grasslands regions of the three prairie provinces for national biomass estimates. Quantified sampling of the various types of forest cover had already been completed under contract. As a starting point, the areas of forest cover, indicated by green shading on the National Topographic Series (NTS) maps at 1:250 000 scale, were produced from aerial survey photography and were known to be accurate. Some of the photography used for the maps, however, was up to 30 years old. The Procom-2 and LANDSAT imagery were used to revise the areas of green shading on 65 NTS map sheets covering the parklands and grasslands regions of the prairies. These maps became the basis for biomass computations for these noninventoried regions under the ENFOR (ENergy from the FORest) program of the Canadian Forestry Service. The same LANDSAT Multispectral Scanner imagery and the Procom-2 have also been considered for softwood-hardwood-mixed wood separations on 1:50 000 scale maps for smaller areas. The limiting factors are manpower and imagery resolution.

Geographic Information System Component

A specific case study demonstrated the concept of converting forest inventory maps and sampling data to biomass inventory maps and statistics on a Geographic Information System (GIS)[3]. The feasibility of using the Procom-2 to economically and accurately provide at least an interim update for the resultant data base was also considered; the Procom-2 offers a practical technique for integrating drawn or otherwise produced maps, up-to-date imagery or aerial photographs, and location-specific supporting data with the digital data base of a GIS. A simplified flow chart (Fig. 2) illustrates the concept.

A sophisticated GIS, however, is not required for map updating. The Procom-2 is also suitable for systematically updating resource or other maps stored in map cabinets. Applications are also not limited to satellite image transparencies. Any positive or negative transparency can be used, particularly if it is in plan form and geometrically compatible with the subject map.

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[2] Unpublished report on mapping of burned forest land in the Northwest Territories available from the author.

[3] Unpublished report on a mapping and analysis of resources system application: forest inventories to biomass inventories, by W.C. Moore and W. Chow, available from the author.

CONCLUSIONS

The Procom-2 is an economic and universal mapping tool for accurate transfers of location-specific information from any transparent medium. It has continuous enlargement capabilities of 2 to 100 times. The outputs from the Procom-2 are the same as from aerial survey techniques for map updating purposes: lines on maps or polygons in digital data bases.

W.C. Moore
May 1986

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